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Quality and Safety Characteristics of Infrared Dried Onion Products

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Abstract. *California produces 75% of the dehydrator onions in the United States. The onions are commonly dried with conventional convective drying which is inefficient and costly. Therefore, this study examined possible advantages of infrared drying for onions. Onions dehydrated using a catalytic flameless gas-fired infrared (FCGIR) drier had a significantly higher drying rate at 70°C when compared to the forced air convection (FAC) drier. Samples dried at 60°C showed no significant difference between the different drying methods. Air recirculation within the FCGIR also did not contribute to increased drying rate. No major differences in quality attributes, namely pungency and color, were found in samples dehydrated by each drying method. Onions dried in the FCGIR drier resulted in better color compared to retail samples of onions powder and minced onions. FCGIR drying could have great potentials for fruits and vegetables.*

Keywords. Infrared, Drying Rate, Dehydration, Onion

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Introduction

Dried onions are an important spice and ingredient for a variety of food applications. Commercially, most dried onions are produced by convective drying, which requires long drying times, has low energy efficiency, and results in poor product quality. It is necessary to investigate new dehydration technologies with high energy efficiency and product quality for such application.

One possible method would be use of an infrared radiation technology with appropriate wavelengths of radiant energy to directly target water. Infrared radiators utilize electromagnetic wavelengths from 760nm to 10,000 μ m in length. Electromagnetic waves in this range create radiant energy. Sandu (1986) shows 80-90% efficiency for infrared heating. Infrared radiation, especially when in selected wavelengths, can effectively target water making it ideal for drying processes. The advantages of radiant heat transfer over convection are that infrared heating has higher heat transfer capability and shorter processing times than convective heating. Additionally, IR heating does not directly raise the air temperature because it is not absorbed by air. Since the infrared drying technology can dry goods at relatively low air temperatures and short time, it could be used to produce dehydrated onions with improved quality (whiter color and higher pungency).

Catalytic flameless gas-fired infrared (CFGIR) has potential to be more energy efficient, easier to maintain, and more environmentally friendly than other types of infrared emitters (Macaluso , 2001). The CFGIR emitter works as natural gas is passed through a preheated emitter which contacts a platinum catalyst pad. The gas, through a flame-less oxidation-reduction reaction, produces radiant energy. CFGIR emitters create medium and far-infrared radiation which is advantageous in thin layer drying applications (Nowak and Lewicki, 2003).

Dehydration of onion has been studied extensively for many years. Most all of the studies examined dehydration using forced hot air convective drying (Krokida *et al.*, 2003; Gowda *et al.*, 1986; Kiranodous *et al.*, 1992). Mathematical models have also been studied extensively for convective drying of onions (Markowski and Zielonka, 1996; Elustondo *et al.*, 1996; Wang, 2002). Likewise, studies have been performed on quality attributes of dehydrated onions but all utilizing convective drying (Adam *et al.*, 2000; Krokida *et al.*, 2001). Past work on utilizing medium and far-infrared in onion dehydration is scarce.

The objectives of this study was to determine the drying rates, pungency degradation, and color characteristics of onions dehydrated using a catalytic flameless gas-fired infrared (FCGIR) and forced air convection (FAC) drying methods.

Methods and Materials

CFGIR Drier Setup

The CFGIR drier arrangement (Figure 1) consisted of a drying chamber (0.95m x 0.65m x 0.65m) with an IR emitter (Catalytic Drying Technologies LLC., Independence, KS) suspended 23 cm from the product drying tray. An aluminum wave guide surrounded the product. Recirculating fans are found on each lateral side of the drier. Product temperature, measured with two T type thermocouples placed beneath the surface of onion slices, determined the cycling on and off of the emitter. A balance (Ohaus Adventurer Pro) measured product weight over drying time. The thermocouples and balance inputs were processed by a connecting personal computer with data acquisition and control software and hardware (Test Point).

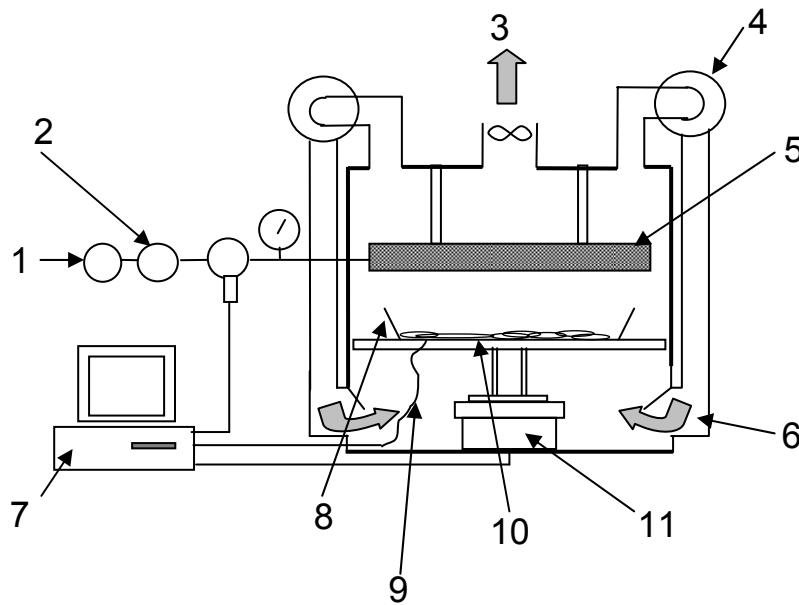


Figure 1: CFGIR Drier: 1- Natural Gas; 2-Gas Flow Control; 3-Exhaust; 4-Blower; 5-CFGIR Emitter; 6-Recirculation Air; 7-Computer Controller; 8-Wave Guide; 9-Thermocouple, 10-Onion Sample; 11-Balance

FAC Drier Setup

The FAC drier consists of a cylindrical shaft (diameter 0.33m) above a blower fan connected to the electric coil heater. Product was placed in a circular mesh tray and suspended by wires to a balance to record moisture loss. Set air temperature was controlled by the same computer setup as the IR drier using a T type thermocouple to measure the dry bulb temperature or the air before it contacted the product.

Sample Preparation

Southport White Globe onions with high solid content (25-28%) obtained from Gilroy Foods (Gilroy, CA) were prepared by removing the top and bottom 20% of the onion and removing the outer dry layers and first fleshy layers. Onions were then sliced perpendicular to the axis into pieces 2.5mm thick. Slices were evenly placed in a single layer on an aluminum mesh screen at the load of 2.5kg/m² and dehydrated in each of the driers.

Drying

7 drying configurations were tested:

- CFGIR 60°C Recirculating fans ON
- CFGIR 60°C Recirculating fans OFF
- FAC 60°C
- CFGIR 70°C Recirculating fans ON
- CFGIR 70°C Recirculating fans OFF

CFGIR 70°C Recirculating fans OFF with fluffing

FAC 70°C

Average air velocity was 0.5 m/s for both driers. Samples were dried to a final moisture content of 8-10% (dry basis). Experiments were done in duplicate. Initial moisture content of onion samples were performed using the vacuum oven method (70°C for 6 hours at 26.1 Hg vacuum) outlined by ADOGA Official Standards and Methods (1997).

Pungency Degradation Tests

Sliced onions were dried in batches of four trays of sample. Trays were removed at 10, 20, 40, and 60 minutes for 70°C experiments and 30, 60, 120, and 180 minutes for 60°C. Trays were weighed and from that moisture content was calculated. Dried products were placed in deionized water to rehydrate and then homogenized using a hand-held homogenizer (Bahmix Bio-Mixer Homogenizer). Slurries were allowed to sit for 30 minutes to allow for enzymatic formation of pyruvate. Pungency was measured using a chemical pyruvic acid assay outlined by Anthon and Barrett (2003). Absorbance was measured on a Beckman DU 7500 spectrophotometer. Inherent, non-enzymatically formed pyruvate was determined by microwaving a fresh sample in an 800 watt microwave oven for one minute and then analyzed using the above assay. Amount of total pyruvate measured was subtracted from the microwave sample to calculate the enzymatically formed pyruvate. Results were shown in percent loss in pungency from a fresh onion sample versus moisture content.

Color Change Tests

L.a.b. color measurements were performed using a Minolta CM-508 spectrophotometer. Each of the onion slurries in the pungency test were tested and additional tests were done for comparison on minced and powder samples from onions dried in the CFGIR drier and retail samples (Powder- Premium onion powder, Gilroy Foods; Minced- Minced onion, McCormick).

Results and Discussion

Drying Rate

For the 60°C CFGIR experiments the drying rates were approximately the same for recirculation fan on and off (Fig. 2). The two IR plots showed instantaneous heating and their maximum drying rates were achieved during the first minute. These plots also did not exhibit typical shape found with drying curves which include a heating rate, a constant rate and a falling rate periods. However, this was seen in the FAC plot where the maximum drying rate was not achieved until a few minutes into the heating and then it exhibited a brief constant rate for several minutes. The short warming and constant rate periods were due, in part, to the high solids content of the onions which have very little free surface water. The overall drying rates of the three conditions were similar.

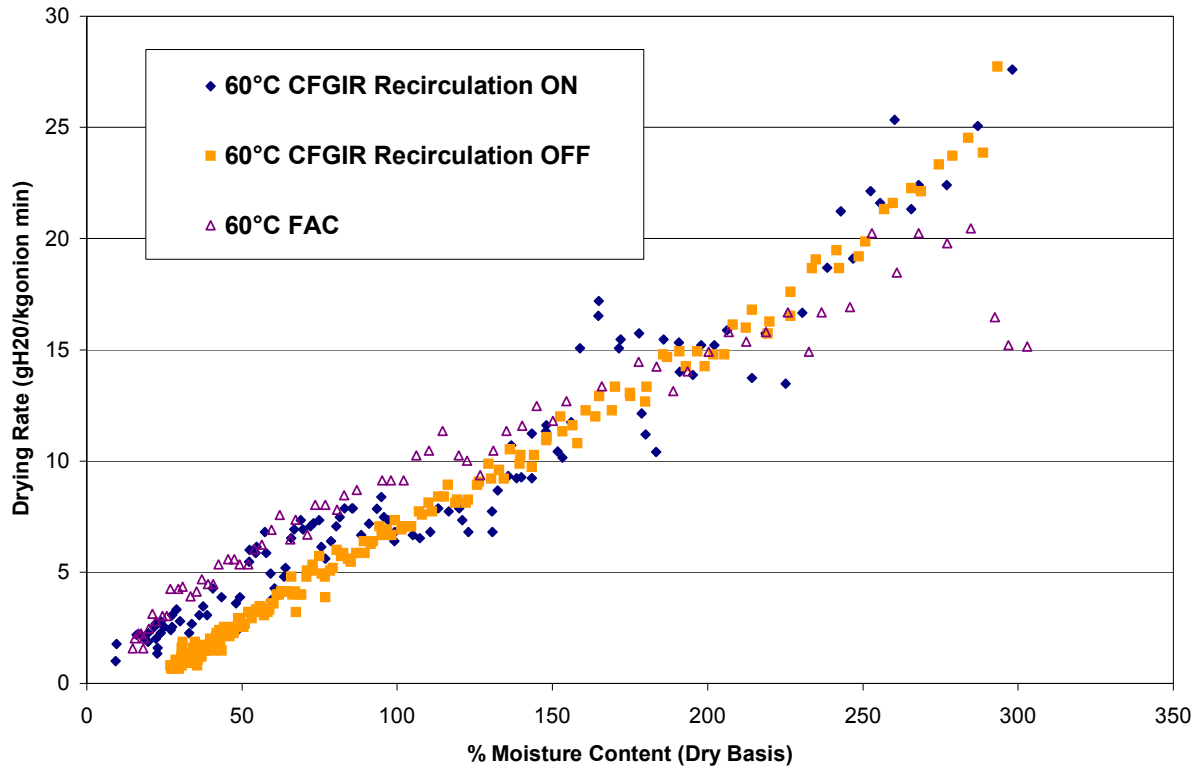


Figure 2. Drying curve at 60°C

The CFGIR drier produced much greater drying rates at 70°C in all three conditions compared to the FAC (Fig. 3). No significant differences were seen in drying rates when air recirculating fans were used in the CFGIR drier. Likewise, “fluffing” or periodic mixing of the samples also did not increase the drying rate at 70°C in the CFGIR drier. This may indicate good infrared penetration into the product. Unlike the 60°C IR plots noticeable warming and constant rate periods were observed for each of the IR plots. This is most likely an effect of the product temperature increasing to the set temperature and not so much an issue of evaporation of moisture from the boundary water layer.

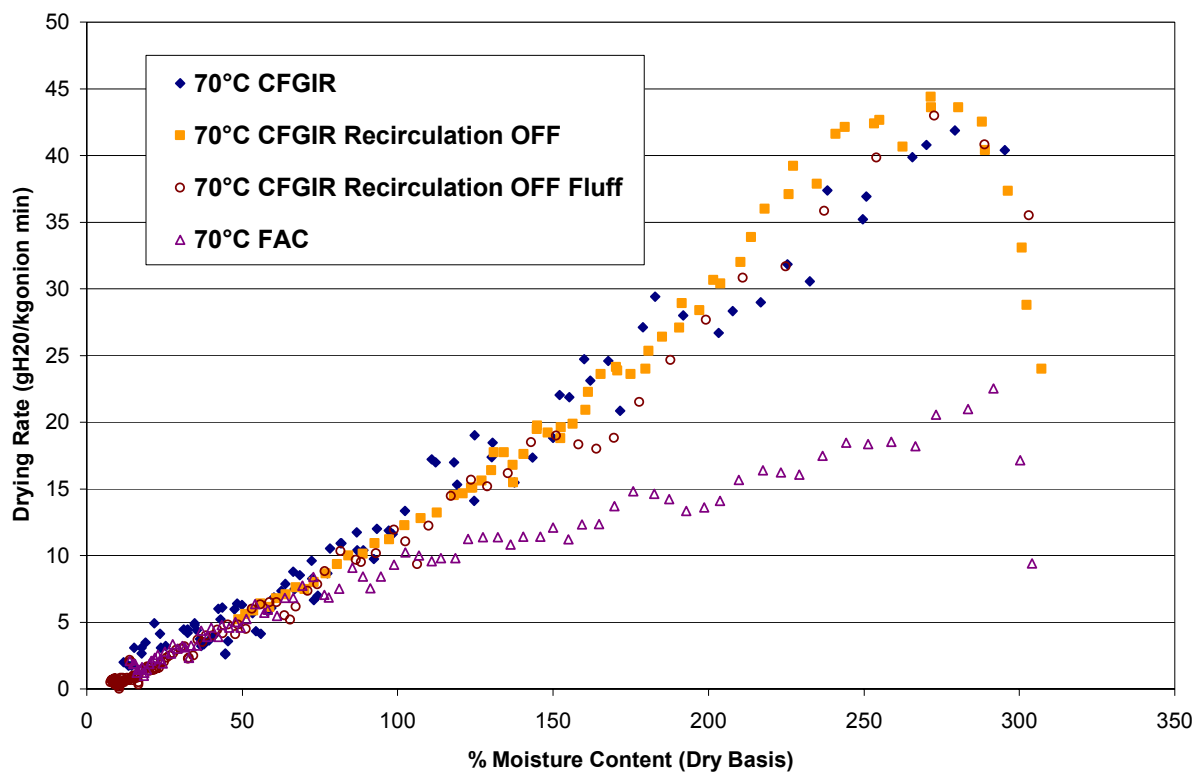


Figure 3. Drying curve at 70°C

Table 1. Maximum Drying Rates for Each Drying Condition

Drying Condition	Maximum Drying Rate (gH ₂ O/kg _{onion} min)
CFGIR 60°C Recirculating fans ON	27.6
CFGIR 60°C Recirculating fans OFF	27.7
FAC 60°C	20.5
CFGIR 70°C Recirculating fans ON	41.9
CFGIR 70°C Recirculating fans OFF	44.4
CFGIR 70°C Recirculating fans OFF with Fluffing	43.0
FAC 70°C	22.5

Pungency Degradation

Pungency, measured in percent reduction of pyruvate compared to a fresh sample, was shown to have great variability but the trends for both driers were similar. At 60°C (Fig. 4) there was no significant differences between the amount of pungency loss between the FCGIR and the FAC

drier. Furthermore the experiments at 70°C (Fig. 5) showed similar trends except that the decrease in pungency was not as profound during the higher moisture content in the FAC drier. This may be a result of lower energy fluxes to the onion surface in the FAC drier compared to the CFGIR drier. Greater energy fluxes may increase inactivation of the enzyme alliinase, which is responsible for the creation of pyruvate and other important flavor components. Although these differences of percent remaining pyruvate were not seen at the end of the drying process where the CFGIR and FAC had similar pyruvate percentages, 75.2% and 74.0%, respectively. This shows that the CFGIR can maintain comparable levels of pyruvate even at greater drying rates.

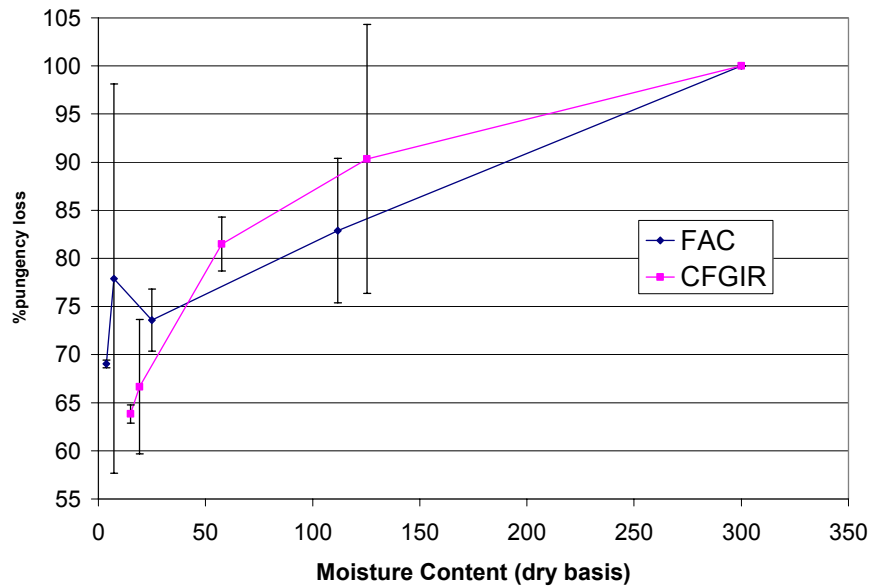


Figure 4. Pungency degradation at 60°C

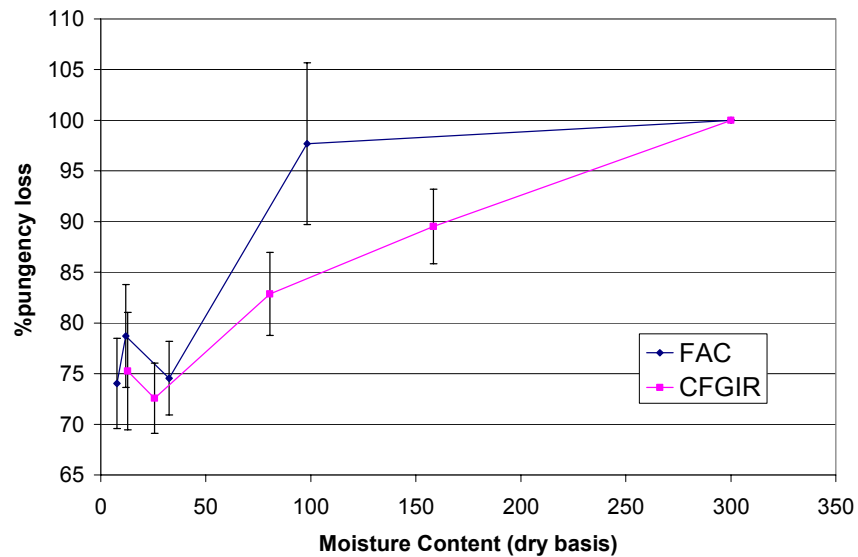


Figure 5. Pungency degradation at 70°C

Color Measurements

Color results showed little differences in onion slurry color from both driers. None of the samples were significantly different on either of the L or b parameters. Values also did not indicate detrimental effects over the drying time. Detrimental color changes can be measured as b values increase indicative of a more yellow, less desirable color and L values decrease indicative of a less white sample which is also undesirable. This may be a result of the final moisture content we were achieving above 10% moisture content. Most of the detrimental effect to the color happened when samples were heated to below this moisture content.

Retail Sample Comparison

Retail onion powder and minced onions were compared to samples prepared in the CFGIR drier. More desirable attributes (whiter and less yellow color) were greater in the sample prepared in the CFGIR drier. When comparing the minced samples the retail sample had an 82% of the b value that the CFGIR sample had (Fig. 6) although the L value was similar for both samples (Fig. 7).

The powdered samples had L values of 90.0, 90.3 and 85.7 for the 60°C CFGIR sample, 70°C CFGIR sample and retail sample, respectively. The b value for the retail powder sample was nearly twice that of the 60°C or 70°C CFGIR sample. Visual differences were noticed when comparing those samples dried with CFGIR dried and the retail samples.

Although a good comparison cannot be made between onion products produced on a pilot scale versus a commercial scale these findings show promise for greater quality attributes using infrared technologies such as CFGIR.

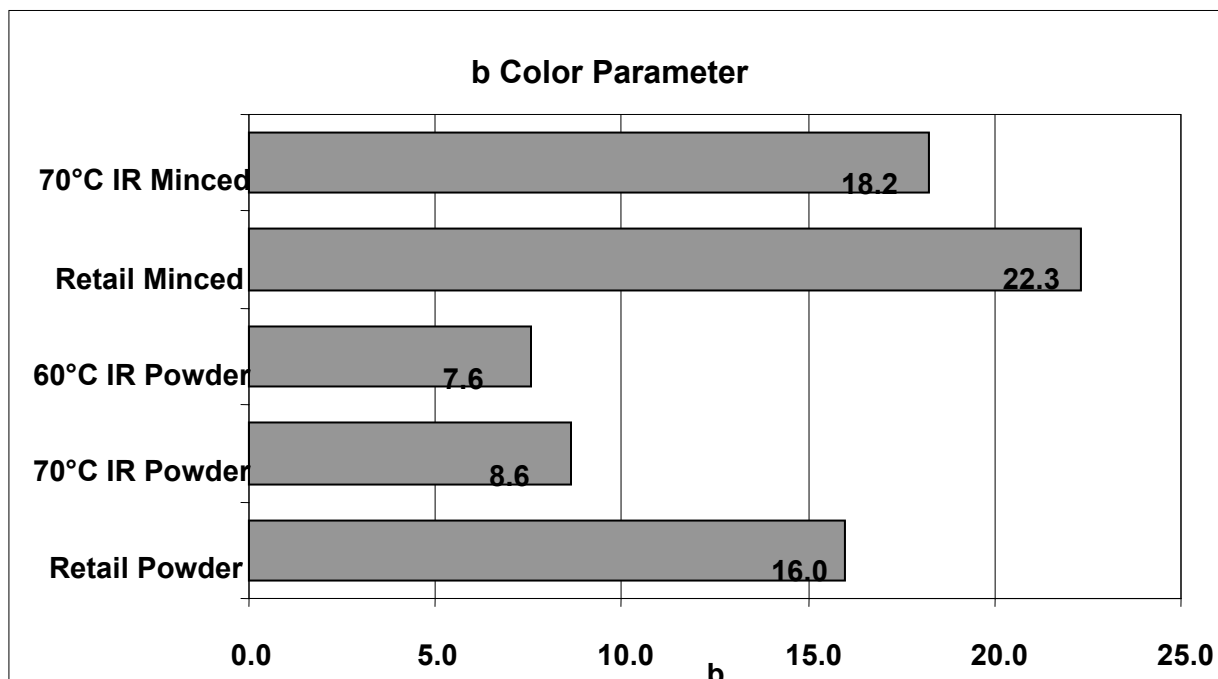


Figure 6. b Color Parameter for CFGIR Dried and Retail Samples

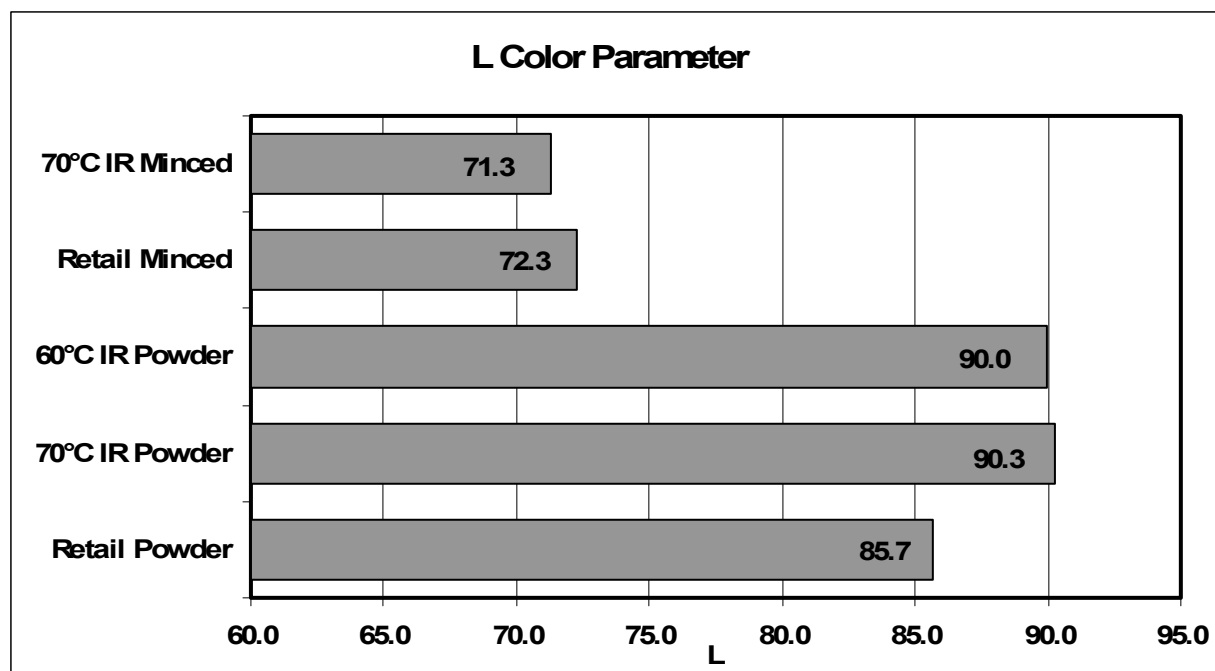


Figure 7. L Color Parameter for CFGIR Dried and Retail Samples

Conclusion

Based on the experiments conducted the following conclusions were made:

- In thin-layer onion drying experiments a pilot scale CFGIR drying exhibited greater drying rates at 70°C compared to conventional drying.
- Air recirculation inside the CFGIR did not have any influence on the drying rate at either of the temperatures that were tested.
- Fluffing the product also did not have a major influence on the drying rate
- Color was more desirable in onions prepared in the CFGIR drier when compared to retail samples.

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